

LABORATORY ENGINE CORRELATION AND *IN-SITU* VALIDATION OF ENGINE TECHNOLOGIES

WHAT IS IT AND WHY IS IT NEEDED?

Engine lubricants and surface engineering technologies (coatings, texturing and surface finishing) offer the opportunity to improve vehicle energy efficiency by up to 10 percent. Once identified in the laboratory, promising new technologies undergo testing under conditions that closely approximate actual use conditions. For cost reasons, it is not practical to test every candidate technology in actual engines on a dynamometer or in the field.

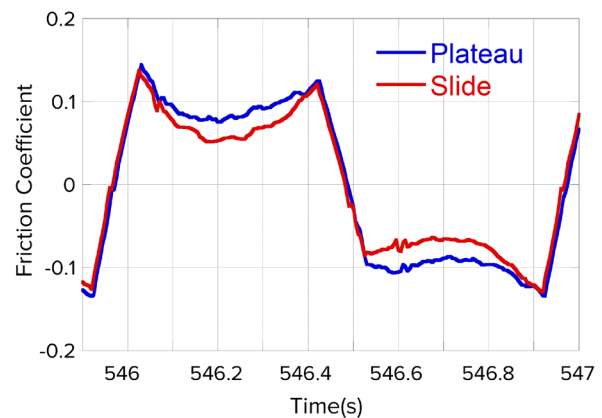
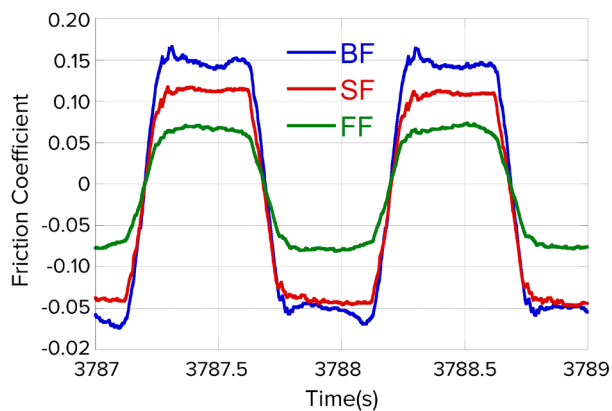
Researchers need cost-effective lab-scale tribological tests that simulate actual engine conditions so they can evaluate new technologies quickly and efficiently. Such lab-scale tests rely on sophisticated instruments and controlled environments. Correlating the results from testing in controlled environments with actual in-engine performance represents the state of the art. Achieving fidelity in those correlations is the ultimate goal, but it is difficult to do, because conditions such as friction loads vary by factors of 100 or more during one revolution of the engine.

Argonne conducts laboratory tests that simulate conditions for engine components such as the pistons, rings, segments of cylinder liners and piston skirts shown above, with a goal of achieving high correlation with in-engine test results.

WHAT IS ARGONNE DOING AND WHY?

Tribology researchers at Argonne National Laboratory leverage a unique combination of expertise and resources to develop high-fidelity testing protocols for lab-scale tribological tests that will lead to open-access information and serve as a platform for validating new technologies that can offer significant fuel savings. Argonne is the ideal organization to conduct this work, by virtue of its multidisciplinary team of experts, unparalleled research facilities, and unbiased approach to testing methods that suit the industry as a whole rather than one company's perspective. As part of a U.S. Department of Energy national laboratory, Argonne's tribology research team conducts the fundamental pre-competitive research that enables companies of all sizes to develop innovative solutions to our nation's pressing energy efficiency, national security and environmental safety challenges—while growing the economy and creating jobs.





Friction waveforms captured using high-speed data acquisition while rubbing two steel surfaces together. The top graph shows reduction in friction with fully formulated oil over semi-formulated oil and base. The bottom graph shows that slide honing enables faster transition from boundary to mixed or hydrodynamic, making it the preferred surface finish.

WHAT HAVE WE ACCOMPLISHED?

Argonne's tribology researchers have achieved the following notable results in their engine correlation efforts

- ▶ Evaluated two different technologies:
 - Surface finish — cylinder liners with different honing preparations
 - Material — piston skirt segments coated with different material coatings
- ▶ Identified factors that influence boundary friction:
 - Tribofilm formation
 - Oil type (manufacturer-additives used)
 - Materials
 - Surface finish
 - Loading conditions (temperature, speed, load)
- ▶ Established a Cooperative Research and Development Agreement to transition testing methodologies to an automotive original equipment manufacturer.

- ▶ Published several peer-reviewed journal articles, detailed below:
 - “Tribological Evaluation of Piston Skirt/Cylinder Liner Contact Interfaces under Boundary Lubrication Conditions,” N.G. Demas, R.A. Erck and G.R. Fenske, *Lubrication Science* **22**(3), 73–87, 2010.
 - “Tribological Studies of Coated Pistons Against Cylinder Liners in Laboratory Test Conditions,” N.G. Demas, O.O. Ajayi, R.A. Erck and G.R. Fenske, *Lubrication Science* **24**(5), 216–227, 2012.
 - “Tribological Effects of BN and MoS₂ Nanoparticles Added to Polyalphaolefin Oil in Piston Skirt/Cylinder Liner Tests,” N.G. Demas, E. Timofeeva, J.L. Routbort and G.R. Fenske, *Tribology Letters* **47**(1), 91–102, 2012.
- ▶ Worked with industry and academia to develop several advanced lubricant additives.

WHERE DO WE GO FROM HERE?

Argonne researchers will focus on correlating laboratory tribological tests with engine tests and validation of new technologies, with a goal of developing an accurate, efficient and low-cost research tool that can evaluate new lubrication technologies.

WHO SUPPORTS THE WORK?

The work described is supported by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Vehicle Technologies Office.